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USING MARK-SENSE CARDS FOR COLLECTING OCCUPATIONAL INFORMATION

By

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ABSTRACT

This study reports on the feasibility of automatic processing of occupational data recorded on IBM mark-sense cards as an alternative to key punching the data written in inventory booklets. 3 administrative procedures were used in collecting information from 367 Air Police (77XXX) incumbents. Comparisons of accuracy, processing time, and costs were made across data-processing methods, skill level, and administrative procedure. With carefully designed inventory and card formats, visual scanning, machine editing, and top maintenance of the IBM reproducer, the mark-sense technique was found feasible, but more expensive than the key-punch method. The 2 administrative techniques, in which incumbents marked whether they performed each task in the inventory before adding unlisted tasks, elicited twice as many write-in statements as the third technique, where incumbents were merely to read the listed statements before adding write-ins. When the incumbents rated tasks for both amount of time spent and training required, the correlation between the ratings was lowest when the first ratings were not visible during the second rating.

Keywords: job inventory administration, mark-sense cards, data collection, data reduction, job description, task ratings, cost estimates, job analysis, job incumbents, Air Police

This report has been reviewed and is approved.

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1. PROBLEM

The job inventory method of collecting, organizing, and reporting information about work performed by incumbents is presented in Air Force Manual 35-2. The present investigation is one of a series of studies designed to further the development of procedures for obtaining quantifiable data from job inventories and punching these data into electronic data processing machine (EDPM) cards.

During the early stages, 1959-1961, of the development of the Air Force occupational analysis method, it appeared that the process of key punching the inventory data by hand might become a major source of delay. The large amount of key punching required at that time prompted an investigation of automatic mark-sense punching technique as a possible alternative. In addition, certain variations of inventory administration were in need of experimental trial.

This study accordingly had two purposes. One was to compare the mark-sense method with the currently used key-punch method in accuracy and economy of punching occupational survey data into cards. The other was to compare three procedures for rating work tasks.

In late 1959 (McCormick & Ammerman, 1960) a job inventory booklet format was developed with photograph mounting corners for holding mark-sense task-rating cards. The cost of these reusuable booklets, however, was excessive; and the time required for loading and unloading the cards was considered prohibitive. An attempt was made to eliminate these objections in the present study.

2. PROCEDURES

Pretests

In early 1959, a standard mark-sense card for recording background information (BI) had been developed to be used with mark-sense test-item cards in the administration of experimental tests. Along the bottom of this card were 18 boxes for the examinee to write his name according to specifications for EDPM use. A column of ovals over each box was provided for mark-sensing. In 1960, this BI card was tried out on a flight of basic airmen to determine its suitability for occupational surveys. The card was found, however, to take a great deal of time and to result in many errors, particularly in writing and mark-sensing the name.

Subsequently the mark-sense BI card and a mark-sense card designed for recording task ratings were tried out. Changes in administrative procedures for the BI card included simplified steps for writing and mark-sensing the name, and the provision on a blackboard of samples of good and poor mark-sensing, plus a list of coded job assignment titles. The job inventory used for this tryout was one for Air Police (AFSC 77XX[illegible]) consisting of 146 task statements grouped under 13 duty headings. This inventory was assembled primarily from materials previously used (Wiley, 1959). In order to facilitate alignment, the task statements were typed so that the spacing matched the mark-sense card columns and were numbered in both margins. The pages of the booklet were printed on one side only, and each duty began on a new page. Write-in tasks, those performed by the incumbent but not listed, were to be added on the pages of the booklet. When the inventory was administered to 17 members of an Air Force Police flight, it was found that the BI card, including the name, took too long to complete. In addition, the use of both sides of the task-rating cards for responding to tasks of the two longer duties, and the necessity for turning these cards back before the next step of the survey could be taken, interfered with smooth administration.

The Main Experiment

In the light of the earlier trials, the inventory booklet, both the BI and task-rating cards, and the administrative directions were revised.

Inventory Booklet. Duties and tasks of the inventory used in the pretest were retained, but the following changes were made in format. The examples of mark-sensing and the list of coded job titles, formerly placed on a blackboard, were printed on the first page of the booklet, and an illustration of the BI card properly filled out was added (see Figure 1). In an effort to reduce the visual demands of responding to the task statements, a type font was used that required only one line for each statement, and the statements were typed by reverse composition so that they ended near the right-hand margin of the page, as shown in Figure 2. A maximum of 25 task statements were listed on each page.

Mark-Sense BI Card. The front of the revised mark-sense BI card was printed with item headings at the top, and a row of boxes for writing digits, as shown in Figure 1. Provision was made for mark-sensing only one letter, the specialty shredout (which does not occur in the Air Police career field). For identification and ready card handling, three items were prepunched and interpreted (machine printed): first two digits (77) of the AFSC, beginning date of the study, and case control number.

The troublesome writing and mark-sensing of the name was eliminated by designing the back of the BI card primarily for items to be written out but not mark-sensed. In addition to space for the incumbent's name, the back of the card provided for writing the Air Force service number, Air Force base, and squadron or unit; and had extra lines for other information. Items such as these, rarely used directly in analysis, were provided so that they could be used for identification, to supplement the case control number, or for whatever cross-referencing might be desired. Eight additional mark-sense columns were included on the back of the card for miscellaneous purposes. The extra lines and mark-sense columns, not used in the present study, were provided to make the card suitable for general occupational survey purposes.

Mark-Sense Task-Rating Cards. As revised, the front of each mark-sense task-rating card had spaces for rating a maximum of 25 tasks; duties with over 25 tasks had two rating cards. One mark-sense card column was provided for responding to each task. The column had two sets of five ovals each for the two ratings, plus an oval on the right for designating the task as done or not done. Cards were reproduced in two slightly different formats: one for the separate-step treatments (covered and uncovered rating) with the right-hand oval to be marked for each task performed by the incumbent; and the other for the single step treatment with the right-hand oval to be marked for each task not performed. (Figure 3 shows a card for the covered rating treatment, designated by the letter *X* in the case control number.) The backs of the task-rating cards were to be used by the incumbents for adding write-in task statements.

Fifteen task-rating cards, one for each page of the inventory, were provided for each incumbent. Of the 13 duties, A through M, all except two had 25 or fewer tasks and required one booklet page and one corresponding card. Duties D and F had 30 tasks each and required two booklet pages and two cards. One additional card was included for tasks of added write-in duties and for miscellaneous write-in tasks. Thus a set for each incumbent had 17 cards: a BI card, 15 task-rating cards, and a card for additional write-in tasks.

Sampling. The inventory was administered to 375 incumbents of the Air Police Career Field (AFSC 77XXX) in groups of 5 to 25, assigned to four installations near San Antonio, Texas. In order to obtain equated subsamples for the three treatments, incumbents available

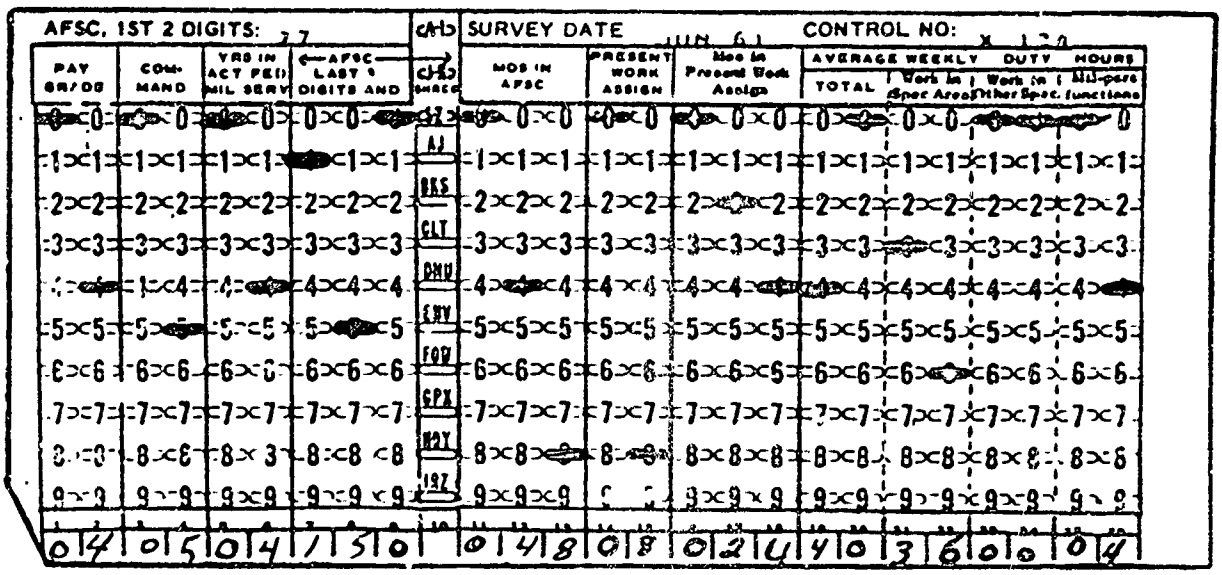

Fig. 1. **BI Card, Front**

7	Conduct inspections of uniforms	7
8	Enforce standards of conduct and adherence to laws and regulations	8
9	Obtain written receipt for airmen accused of civil crimes when they are released to civil police	9
10	Secure restricted areas and scenes of disaster	10
11	Patrol property concentration areas such as warehouses, hangars and motor pools, to prevent sabotage and pilferage	11

Fig. 2. **Sample of format for listing task statements.**

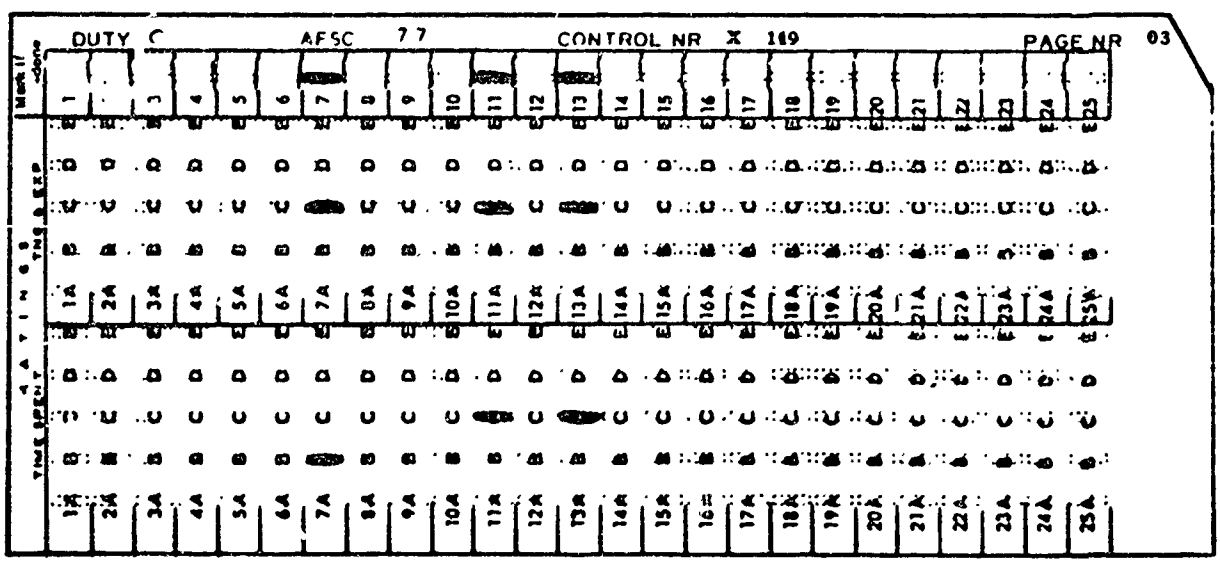

Fig. 3. **Task-rating Card, front.**

for each survey session were stratified into categories: first by Primary AFSC; then, within each AFSC, by military grade (for example, 77150-staff sergeants (E-5)). During the course of the survey, numbers of incumbents listed as available for a given session were distributed among the three treatments so that the cumulative totals of the categories were kept as nearly equal as possible. Individuals to be assigned on this basis to the three treatments were selected by use of a table of random numbers. Inequalities of treatment distributions resulting from absentees and extra incumbents at a survey session were adjusted in making assignments for the following sessions. Although there were 125 cases in each of the treatments, eight cases of the covered rating treatment had to be discarded because of an error in administration. Only 9 of the 367 remaining incumbents were in the Correction Ladder (77XX1); the other 358 were in the conventional Air Police Ladder (77XX0). Moreover, the 9 skill level had only one case; and the 1 skill level only 11; the other 355 were in the 7, 5, and 3 levels.

The specialty (Primary AFSC) and grade distributions for the three treatments, shown in Table 1, indicate a high degree of equivalence as estimated by the chi-square test for distributions assumed to have been randomly selected from the same parent population. For computation of chi square, small AFSC entries were combined with larger entries to form three groups: 9 and 7 skill level, 5 level, and 3 and 1 level. Similarly combinations were made of the top four and the bottom two grade entries to give five groups.

Table 1. **Distribution of Treatments by AFSC and by Grade**

	TREATMENT		
AFSC	COV	UNCOV	1 STEP
[77190	0	0	1
77171	2	2	0
77170]	10	10	11
[77151	1	1	3
77150]	83	86	88
[77131	0	0	0
77130	18	23	17
77010]	3	3	5
Total	117	125	125

$\chi^2 = .55$, df = 4, P = .97

	TREATMENT		
GRADE	COV	UNCOV	1 STEP
[E-9	0	0	0
E-8	0	0	1
E-7	1	1	0
E-6]	4	5	4
E-5	26	23	24
E-4	34	41	39
E-3	37	40	41
[E-2	15	14	15
E-1]	0	1	1
Total	117	125	125

$\chi^2 = .93$, df = 8, P > .99

Note.—Bracketed entries combined in computing χ^2.

Treatments. The covered rating treatment provided for five steps of administration: (a) filling out and mark-sensing the BI card; (b) reading the tasks and mark-sensing the "Mark if done" oval for each task performed; (c) adding write-in tasks on the backs of task-rating cards and on the extra write-in card; (d) rating every task performed on total time spent; and (e) rating every task performed on training and experience required to accomplish the task adequately. All ratings were to be made on an ipsative basis. The second rating was made with

the rating card partly under the inventory page so that the first rating could not be seen. This treatment was designed to exclude opportunity for the second rating of a task to be influenced by the first rating.

The uncovered rating treatment consisted of the same five steps as the covered rating treatment, with one difference: the second rating was made without covering the first rating. The likelihood of the second rating being influenced by the first was expected to be greater than in the covered rating treatment.

The single-step rating treatment required the incumbent: to complete the BI card; to read the listed tasks and add write-in tasks; and for each task, *either* to mark the oval labeled "Mark if *NOT* done," *or* to make the two ratings before going on to the next task. The single step rating treatment proved to be the most easily and quickly administered. This treatment, however, was expected to offer the greatest likelihood of the second rating being influenced by the first.

Administration. A set of administrative directions was prepared for each treatment. Experienced test administrators conducted the survey sessions. They were assigned to the three treatments in rotation to keep the conditions of administration as nearly balanced as possible.

Data Processing. The visual hand-scanning and correction prior to machine processing included: erasing multiple responses to the same factor, responses where only one factor was rated, stray and poorly erased marks and marks extending beyond ovals; blackening light marks; and marking BI data recorded in writing but not mark-sensed.

Machine processing was done in several steps. Automatic punching from BI and task-rating mark-sense cards to punch cards was done on the reproducer (IBM 519). Rating marks labeled A through E on mark-sense rating cards, but regarded as quantities 1 to 5 for analysis, were punched, without conversion, according to their position on the mark-sense card column, regardless of the digits normally represented by these positions. Punching for the two ratings was in separate punch card columns. Punches were made in both rating columns for the tasks marked as done (in the case of the covered and uncovered rating treatments) and for the tasks marked not done (in the case of the single-step treatment).

The deck of punch cards thus produced was edited by use of the statistical sorter (IBM 101). BI punch cards with missing information were sorted out. Task-rating cards sorted out were those with one or more instances of incompatibility between rating punches or lack of punches on the one hand and punches to indicate tasks done or not done on the other hand. These rejected punch cards were then matched on the collator (IBM 089) with their corresponding mark-sense source cards. Errors were hand-corrected on BI and task-rating mark-sense cards, and corrected punch cards were made on the reproducer or key punch (IBM 024).

The corrected punch card deck was reproduced with task-done and task-not-done punches omitted and with a zero punch added for each of the two rating columns having no rating punches. A second editing sorted out cards with incompatibilities between zero and rating punches in the same column and between zero punches of the two columns for the same task; corrections were made as before.

The sorter (IBM 083) and interpreter (IBM 557) were used during the machine processing as needed to re-sort and to replace interpreted data on corrected punch cards.

In order to have a deck to compare with the deck automatically produced from mark-sense cards, operators punched the same data by hand on the key punch. They read the responses from the mark-sense source cards as if such data had been recorded on inventory booklet pages. Ratings labeled A to E were punched as 1 to 5. In the case of responses written and also mark-sensed, the written responses were followed except in the case of obvious errors such as

out-of-range ratings. Routine checking was done on the verifier (IBM 026). The resulting deck of key punch cards and the deck of punch cards automatically produced from mark-sense cards were to be compared by the collator. Before the comparison was made, however, the rating cards of the mark-sense punch deck were converted on the computer (IBM 650). The punches for 1 to 5 and zero were made in the column positions normally representing these digits, as on the key punch deck.

In order to compare the converted mark-sense punch deck with the key-punch deck, a machine roster was made, on the accounting machine (IBM 407), of each pair of cards of the two decks having one or more differences in punches; and the differences were visually identified and labeled. The erring version, mark-sense or key punch, was ascertained by visually comparing each discrepancy on the roster with the original datum on the mark-sense source card.

Analysis. The procedure for analyzing the differences in accuracy of punching between the mark-sense and key-punch methods included grouping incumbents by administrative treatment and skill level. This grouping was also used for the analysis of differences in the effect of the three treatments. Because of small numbers, incumbents in skill level 9 were combined with those in level 7, those in level 1 were combined with those in level 3, and incumbents in the Correction Ladder (77XX1) were combined with those in the conventional Air Police Ladder (77XX0). Thus nine groups were formed according to treatment (covered rating, uncovered rating, and single-step rating) and skill level (9-7, 5, and 3-1). For the comparison of the mark-sense and key-punch methods in terms of types of rating punch errors, and in terms of time and dollar economy of processing, the grouping was by treatment only.

In the analysis of punching accuracy, BI and identification errors were compared by number alone; but for errors of rating, both number and percentage of total possible errors (in terms of cases, cards, and punches) were used. The possible number of rating punch errors for computing percentages was taken to be the total number of punches where tasks had been actually rated on both factors; zero punches were excluded as representing omissions, not ratings. Inclusion of zero punches would have resulted in a large spurious deflation of percentages. In counting errors, however, an omission punched as a rating, as well as a rating punched as an omission, were included as punching errors. The punching of multiple responses to the same factor or of responses where only one factor was rated as anything except zero was also counted as an error. In computing the percentages of cards with one or more rating punch errors, the possible number of cards was taken to be the number having one or more tasks rated on both factors.

Further analysis of rating punch accuracy consisted of a comparison of statistics computed from data produced by the mark-sense and key-punch methods with statistics computed from corrected data. Statistics compared were: number of tasks rated, mean and standard deviation of the two ratings, and correlation between the ratings.

In the comparison of types of rating punch errors between the mark-sense and key-punch methods, only number of errors was used. Likewise, number of hours and dollars was used in the comparison of time and cost economy.

The comparison of the three treatments to determine differential effect of the first rating on the second was made in terms of correlation between the two ratings, computed from the corrected data.

3. RESULTS

Survey Administration

In the administration of the survey, smoothness of procedure conformed to accepted standards. The overall time for administration ranged from 75 to 90 minutes for the covered and uncovered rating treatments and from 60 to 75 minutes for the single-step treatment. In each treatment, the BI card took about 14 minutes. On the basis of the time required for this 146-task inventory, it is estimated that an inventory with 300 task statements of the same type could be administered in about two and one-half hours for the covered and uncovered rating treatments, and in about two hours for the single-step treatment.

Processing Accuracy

BI Card Errors. Only 6 errors were found in the 367 mark-sense BI punch cards. Three coded job assignment titles were incorrectly punched although correctly recorded on mark-sense cards. The other three errors were attributed to incorrect mark-sensing which had escaped the scrutiny of the scanners. No errors were found in the key punch BI cards.

Task-Rating Card Errors. In the 5505 cards of the mark-sense task-rating punch deck, the code number for machine-room identification of the study was omitted from 7 cards which had been repunched. This code number was originally gang-punched. In the key-punch task-rating deck, the duty letter was incorrectly punched on three cards.

Of the 5505 pairs of task-rating cards produced by the two processing methods, 2857 contained no entries because tasks were not performed by the raters. Of the 2648 pairs of cards with at least one task rated, 238 pairs had one or more rating punch differences, for a total of 477 discrepancies in rating punches between the mark-sense and key-punch versions, as shown in Table 2. The data given are the number and percentage of task-rating errors for each method, by treatment and skill level. No definite trends related to skill levels appeared in the table. Errors were computed in terms of cards and cases as well as punches to ascertain whether there was a tendency for errors to be concentrated on a few cards or cases. Since no such concentration appeared, further consideration of errors will be in terms of punches only.

The standard error formula used to compute the significance of the difference between the percentages of errors for the mark-sense and key-punch methods is one suitable for correlated samples with small *N*s and small percentages (McNemar, 1949, p. 80): the percentage of the two samples combined is used in place of the separate percentages appearing in the conventional formula. As may be seen in Table 2, the key-punch method was consistently more accurate than the mark-sense method. Of the 48 comparisons made, 7 had *N*s and percentages too small to justify use of the *t* technique (McNemar, 1949, p. 80). All of the totals for treatments and skill levels show differences significant beyond the .001 level.

The mark-sense method had punching error percentages, for all three treatments, in excess of the 1 percent considered as the maximum tolerable for experimental test scoring. The key-punch method, on the other hand, had only negligible percentages for the treatments and a grand total of only .1 percent.

Table 3 shows the frequency of different types of errors made in rating punches. It is apparent that the number of mark-sense recording errors uncorrected by visual scanning and machine editing was negligible for all treatments. The type of error occurring most frequently in the covered and uncovered rating treatments of the mark-sense method was "omission, but 1 to 5 punched"; whereas the most frequently occurring type in the single-step treatment was

Table 2. **Distribution of Rating Punch Errors Made in Mark-Sense (MS) and Key-Punch (KP) Methods**

SKILL LEVEL	UNIT	COVERED N	COVERED NO. ERRORS MS	COVERED NO. ERRORS KP	COVERED PERCENT MS	COVERED PERCENT KP	UNCOVERED N	UNCOVERED NO. ERRORS MS	UNCOVERED NO. ERRORS KP	UNCOVERED PERCENT MS	UNCOVERED PERCENT KP	SINGLE STEP N	SINGLE STEP NO. ERRORS MS	SINGLE STEP NO. ERRORS KP	SINGLE STEP PERCENT MS	SINGLE STEP PERCENT KP	ALL TREATMENTS N	ALL TREATMENTS NO. ERRORS MS	ALL TREATMENTS NO. ERRORS KP	ALL TREATMENTS PERCENT MS	ALL TREATMENTS PERCENT KP
9-7	case	12	7	1	58.3	8.3*	12	6	1	50.0	8.3*	12	8	0	66.7	0.0*	36	21	2	58.3	5.6
	card	125	13	1	10.4	0.8	149	7	1	4.7	0.7*	131	15	0	11.5	0.0	405	35	2	8.6	0.5
	pnch	1334	48	1	3.6	0.1	1670	15	2	0.9	0.1	1530	20	0	1.3	0.0	4534	83	3	1.8	0.1
5	case	84	27	1	32.1	1.2	87	30	4	34.5	4.6	91	41	1	45.1	1.1	262	98	6	37.4	2.3
	card	511	44	1	8.6	0.2	672	51	5	7.6	0.7	658	56	1	8.5	0.2	1841	151	7	8.2	0.4
	pnch	4446	109	2	2.5	0.0	5636	97	7	1.7	0.1	5570	62	1	1.1	0.0	15652	268	10	1.7	0.1
3-1	case	21	9	0	42.9	0.0*	26	8	2	30.8	7.7*	22	8	1	36.4	4.5*	69	25	3	36.2	4.3
	card	116	15	0	12.9	0.0	155	15	2	9.7	1.3	131	10	1	7.6	0.8	402	40	3	10.0	0.7
	pnch	718	29	0	4.0	0.0	922	66	2	7.2	0.2	860	15	1	1.7	0.1	2500	110	3	4.4	0.1
All	case	117	43	2	36.8	1.7	125	44	7	35.2	5.6	125	57	2	45.6	1.6	367	144	11	39.2	3.0
	card	752	72	2	9.6	0.3	976	73	8	7.5	0.8	920	81	2	8.8	0.2	2648	226	12	8.5	0.5
	pnch	6498	186	3	2.9	0.0	8228	178	11	2.2	0.1	7960	97	2	1.2	0.0	22686	461	16	2.0	0.1

* The *t* test of significance not applicable. All other differences between percentages of MS and KP significant at the .01 level.

"1 to 5 marked, but zero punched." Since this last type accounted for 84 of the 97 errors in the single-step treatment of the mark-sense method, and since this kind of error is due to machine rather than to operator failure, the mark-sense cards were rerun through a reproducer after an IBM engineer had made a maintenance check. In this rerun only 15 punching errors were made: 4 "wrong digit (1 to 5) punched"; 3 "omission, but 1 to 5 punched"; and 8 "1 to 5 marked, but zero punched." Eight of the errors repeated errors made in the original run because of uncorrected mark-sense marks; the other seven were new errors. The rate of punching errors for this mark-sense rerun, 15 of a possible 7960, was only .2 percent. These rerun punch cards were not used for any of the tabulations of this study.

Table 3. **Distribution of Rating Punch Errors by Types of Errors**

TYPE OF ERROR	MARK-SENSE METHOD				KEY-PUNCH METHOD			
	COV	UNCOV	1-STEP	TOT	COV	UNCOV	1-STEP	TOT
Wrong digit (1 to 5) punched	52*	33	3	88	0	2	0	2
Omission, but 1 to 5 punched	72	118*	2	192	1	3	0	4
1 to 5 marked, but zero punched	59	20	84	163	2	6	2	10
Uncorrected mark-sense error	3	7	8	18	-	-	-	--
Total	186	178	97	461	3	11	2	16

*One out-of-range punch (6-9) included.

Table 4 presents, by treatment and skill level, the number of tasks rated and summary statistics computed from data of the mark-sense punch-card deck, data of the key-punch deck, and corrected data. It shows means and standard deviations of the ratings for time spent (TS) and training and experience (T&E) and correlations between the ratings. Two definite trends related to skill levels appear in the table, both of which have been observed in other studies (Gragg, 1962).[1] Those of higher levels rate more tasks and rate training and experience higher. In spite of substantial discrepancies in the number of tasks shown as rated, especially by the data of the mark-sense method, the differences between the summary statistics from corrected data are small. The largest difference for a mean is .05; for a standard deviation, .02; and for a correlation, .01.

Economy of Processing

To compare the cost, in hours and in dollars, of the method of key punching from inventory booklets with that of the mark-sense method, it was necessary to estimate the time that would have been expended in key punching the source data of the present study

[1] And unpublished surveys carried out by the Personnel Research Laboratory (PRB) under the direction of Dr. J. E. Morsh.

Table 4. Statistics of Time Spent (TS) and Training and Experience (T&E) Ratings Computed From Mark-Sense (MS), Key-Punch (KP), and Corrected (Cor) Data

STATISTIC	COVERED RATING			UNCOVERED RATING			SINGLE STEP			ALL TREATMENTS		
	MS	KP	COR	MS	KP	COR	MS	KP	COR	MS	KP	COR
	9-7 Level: 12 cases			*9-7 Level: 12 cases*			*9-7 Level: 12 cases*			*9-7 Level: 36 cases*		
Tasks Rated	654	667	667	835	836	835	746	765	765	2235	2268	2267
Mean of TS	2.51	2.50	2.50	2.80	2.80	2.81	2.79	2.82	2.82	2.71	2.72	2.72
SD of TS	1.29	1.29	1.29	1.23	1.24	1.24	1.36	1.37	1.37	1.30	1.30	1.30
Mean of T&E	3.23	3.22	3.22	3.13	3.13	3.13	3.29	3.31	3.31	3.21	3.22	3.22
SD of T&E	1.09	1.09	1.09	0.95	0.96	0.96	1.17	1.18	1.18	1.07	1.08	1.08
r of TS-T&E	.29	.30	.30	.46	.46	.46	.55	.56	.56	.44	.45	.45
	5 Level: 84 cases			*5 Level: 87 cases*			*5 Level: 91 cases*			*5 Level: 262 cases*		
Tasks Rated	2188	2222	2223	2826	2816	2818	2730	2784	2785	7744	7822	7826
Mean of TS	2.41	2.42	2.42	2.62	2.62	2.62	2.55	2.57	2.57	2.53	2.54	2.54
SD of TS	1.28	1.28	1.28	1.37	1.37	1.37	1.39	1.39	1.39	1.35	1.36	1.36
Mean of T&E	2.90	2.91	2.90	2.99	2.99	2.99	3.00	3.02	3.02	2.97	2.97	2.97
SD of T&E	1.11	1.11	1.11	1.22	1.21	1.21	1.08	1.09	1.09	1.14	1.14	1.14
r of TS-T&E	.29	.30	.30	.38	.38	.38	.42	.43	.43	.37	.38	.38
	3-1 Level: 21 cases			*3-1 Level: 26 cases*			*3-1 Level: 22 cases*			*3-1 Level: 69 cases*		
Tasks Rated	356	359	359	478	459	461	417	429	430	1251	1247	1250
Mean of TS	2.51	2.51	2.51	2.60	2.58	2.58	2.43	2.45	2.45	2.52	2.51	2.52
SD of TS	1.40	1.40	1.40	1.31	1.31	1.31	1.29	1.31	1.31	1.33	1.34	1.34
Mean of T&E	2.81	2.80	2.80	2.84	2.79	2.79	2.66	2.66	2.67	2.77	2.75	2.75
SD of T&E	1.18	1.19	1.19	1.18	1.19	1.20	1.17	1.17	1.17	1.18	1.18	1.19
r of TS-T&E	.40	.41	.41	.51	.52	.51	.75	.75	.75	.56	.56	.56
	All Levels: 117 cases			*All Levels: 125 cases*			*All Levels: 125 cases*			*All Levels: 367 cases*		
Tasks Rated	3198	3248	3249	4139	4111	4114	3893	3978	3980	11 230	11 337	11 343
Mean of TS	2.44	2.44	2.44	2.65	2.65	2.66	2.58	2.60	2.60	2.57	2.58	2.58
SD of TS	1.30	1.30	1.30	1.34	1.34	1.34	1.38	1.38	1.38	1.34	1.35	1.35
Mean of T&E	2.96	2.96	2.96	3.00	3.00	2.99	3.02	3.03	3.04	2.99	3.00	3.00
SD of T&E	1.12	1.13	1.13	1.17	1.17	1.17	1.12	1.13	1.13	1.14	1.14	1.14
r of TS-T&E	.30	.31	.31	.41	.41	.41	.49	.50	.50	.41	.41	.41

from responses recorded in inventory booklets instead of on mark-sense cards. For this estimate, time actually spent on key punching and verifying similar inventory booklet data of previous studies was used (Gragg, 1962).[2] For the mark-sense processing time, the hours reported for this study by the key-punch supervisor were used. Time spent on programming and on wiring control panels for machine operation was not included because it would be expended only on a one-time basis during planning and setting up a mark-sense processing system. The time in hours, by treatment, is given for the two processing methods in Table 5.

Table 5. **Time Required for Punching Cards by the Mark-Sense Method and the Key-Punch-Method**

	MARK-SENSE METHOD			KEY-PUNCH METHOD
TREATMENT	MAN HOURS (SCANNING)	MAN-MACHINE HOURS	TOTAL HOURS	MAN-MACHINE HOURS[a]
Covered	19.40	11.57	30.97	16.52
Uncovered	20.62	11.52	32.14	17.50
Single Step	4.95	7.35	12.30	17.50
Total	44.97	30.44	75.41	51.52

[a] Estimated from time required for punching similar data from inventory booklets.

According to Table 5, the mark-sense cards of the treatments (covered and uncovered) requiring two rating steps took much more time to process than did those of the single-step treatment. The difference was due to the format of the cards. The separate-step cards called for blank columns for tasks not performed and columns with three marks for tasks performed, one mark for performance and two for ratings. The single-step card columns provided for two rating marks for tasks done and one mark for tasks not done. The time spent in the development of a processing system for the two-step card was included in the hours reported by machine operators for the processing itself. No developmental time was required for the single-step card system, already in use for punching test item cards. Accordingly the time for processing the single-step cards was regarded as representative of the operational mark-sense processing, and was used in comparing the mark-sense with the key-punch method. As shown in Table 5, the total time for processing the 125 cases of the single-step treatment was 17.5 hours for the key-punch method and 12.3 hours for the mark-sense method, about 30 percent less.

[2] And an unpublished study carried out by Personnel Research Laboratory (PRB) under the direction of Lt Col J. L. Madden.

Estimates of the dollar costs of the mark-sense and key-punch methods of punching the single-step cards are given in Tables 6 and 7. Machine-hour cost was computed from the monthly charge on the IBM basis of 176 hours per month. Man-hour costs were computed according to local wage rates, with no allowance for supervisor pay. In computing card cost, the standard price per thousand was used, and no allowance was made for wastage. The cost of processing the 125 cases of the single-step treatment was $32.06 for the key-punch method and $42.44 for the mark-sense, about 32 percent more.

Table 6. **Cost of Punching Single-Step Cards by Mark-Sense Method**

MACHINE COSTS	NO. HRS	COST PER HR	COST	
Sorter (083)	0.83	$0.76	$ 0.63	
Collator (089)	1.50	1.25	1.88	
Stat Sorter (101)	1.72	2.84	4.88	
Reproducer (519)	3.13	1.63	5.10	
Interpreter (557)	0.17	1.04	0.18	
Machine Total				$12.67
OPERATOR COSTS				
Machine Operation	7.35	2.35	17.27	
Scanning	4.95	1.50	7.42	
Operator Total				$24.69
MATERIALS	**NO.**	**COST PER M**		
Punch Cards	4000	1.27		$ 5.08
			TOTAL	$42.44

Table 7. **Cost of Punching Single-Step Cards by Key-Punch Method**

MACHINE COSTS	NO. HRS	COST PER HR	COST	
Key Punch (024)	9.23	$0.24	$2.22	
Verifier (026)	8.27	0.30	2.48	
Machine Total				$ 4.70
OPERATOR COST				
Machine Operation	17.50	1.50		$26.25
MATERIALS	**NO.**	**COST PER M**		
Punch Cards	875	1.27		$ 1.11
			TOTAL	$32.06

Effect of Administrative Treatments

As shown in Table 4 under the corrected data columns, the correlations of the time-spent ratings with the training-and-experience ratings, for all skill levels combined, are .31 for the covered rating, .41 for the uncovered rating, and .50 for the single-step treatment. The differences ($P<.01$, as computed by the z-transformation technique) are appreciable in size and are in the direction expected.

The number of listed tasks rated and the number of write-in task statements added were not hypothesized to be affected by differences in administrative treatments. The average numbers of tasks rated, by each case, based on the corrected data columns of Table 4, show only negligible differences between the three treatments. In the production of write-in statements, however, not shown in the table, each of the covered and uncovered rating treatments resulted in 118 statements for all levels combined while in the single-step treatment only 57 statements were obtained.

4. DISCUSSION

Survey Administration

The administrative procedures adapted from the booklet recording technique to the mark-sense recording method proved to be satisfactory. The overall administrative time estimates reported make no allowance for greater speed, due to familiarity with mark-sensing, that could be expected on the latter items of a longer inventory. It was apparent also that time could be saved by shortening the administrative directions. It seems likely, therefore, that an inventory of 300 comparable task statements could be administered by any one of the treatments within a time limit of about two hours. This estimated time is comparable to that required for similar inventories currently used with responses recorded in booklets.

Processing Accuracy

The key-punch method was found to be highly accurate for both BI and task-rating cards, as may be expected when all data are checked on the verifying machine (IBM 026). For the mark-sense method, the punching accuracy for data on BI cards and for the identification data on task-rating cards was also satisfactory. The processing of rating responses on the mark-sense cards, however, was not so accurate as desired since the errors made in punching ratings in all three treatments were in excess of the 1 percent generally considered as the maximum tolerable. In spite of these inaccuracies, the summary statistics computed from the mark-sense data showed only negligible deviations from the correct statistics. It might be concluded that the mark-sense method is quite adequate for purposes of occupational analysis research. This conclusion would hold, however, with an error rate greater than 1 percent, only so long as errors are unbiased, as they apparently were in this study. Since errors might well occur systematically, the error rate must be kept below 1 percent if the conclusion is to hold. The rating-punch error rate (.2 percent) of the rerun of the single-step cards indicates that highly accurate punching can be obtained with a reproducer. Unless the reproducer is maintained in top condition, however, mark-sense processing cannot be depended upon without additional verification.

Economy of Processing

The mark-sense method showed 30 percent fewer man and machine hours than the key-punch method. Since, however, the typical data processing organization has several key punch and verifier machines for every reproducer or statistical sorter, the apparent time advantage

of the mark-sense method is actually not meaningful. In dollar economy, also, the mark-sense method failed to show an advantage. Because wages paid to machine room technicians are higher than those paid to key punch operators and clerical personnel, the dollar cost of the mark-sense method turned out to be 32 percent more than that of the key-punch method.

Effect of Administrative Treatments

Having the first rating covered while making the second resulted in the least correlation between factor ratings; the single-step treatment procedure of making both ratings of each task before proceeding to the next task produced the largest correlation; and the currently used technique of making ratings in separate steps but with the first in view during the recording of the second showed correlation intermediate in size.

In the production of write-in task statements, both of the separate-step treatments were superior to the single-step treatment, apparently because the incumbents were required to indicate whether or not every listed task was done before adding tasks that were not listed. Asking incumbents merely to read the listed tasks before adding task statements produced less than half as many write-ins. The difference between the separate-step treatments and the single-step treatment in terms of the number of listed tasks rated, however, proved to be negligible.

5. CONCLUSIONS

Correlation between rating factors is reduced by having previous ratings out of sight while later ratings are made.

Requiring incumbents to respond to listed tasks beforehand increases the production of write-in task statements.

The mark-sense method of producing punch cards offers some man-hour economy. The period of time required for producing a given amount of punch cards, however, will normally be less for the key-punch method because of the number of key punch and verifier machines in a typical data processing organization.

In dollar cost, the mark-sense method is more expensive than the key-punch method because machine technicians are paid more than key punch operators.

The key-punch method, including verification of all punching, is more accurate than the mark-sense method. The mark-sense method, however, is satisfactorily accurate when the reproducer is properly maintained.

The mark-sense method of producing punch cards, while feasible, has no apparent advantage over the key-punch method in the collection of occupational data.

Marking nonperformance rather than performance of tasks may reduce the time required in working out a mark-sense processing technique, but once the technique is developed should make no difference in either accuracy or economy.

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